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TELESCOPE CONTROL SYSTEM SOFTWARE

User Manual

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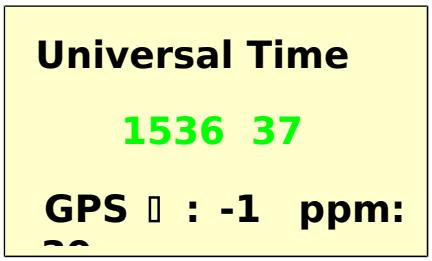
Interface

2

1 Overview of the Telescope Control System (TCS)

2 Telescope Control System Interface

2.1 Universal Time Display



The GPS is a special unit that controls time. This unit is connected to TCS computer. The symbol is the difference between GPS time value and TCS time value, The time value is good when this delta is equal to 0.

The ppm is a variable that is used to synchronize the TCS computer time value with GPS time.

2.2 Focus Information Display

	Z	Focus
Set:	800	
Ima:	32	
Psn:	45	
Tmp:	791	
Off:	0	
Req:	1668	
Val:	1306	

	X	Y
Set:	0	0
Ima:	-997	-127
Psn:	-3867	-1681
Req:	-4864	-1808
Val	-4051	-1818

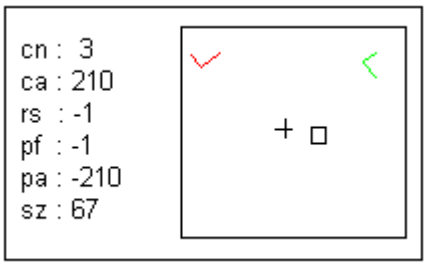
	H	V
Set:	0	0
Ima:	163	51
Psn:	65	-98
Req:	228	-47
Val:	212	-48

The variables in this interface shows the actual secondary mirror position. This information is collected by Vane End Control System:

- Set: position value required by user
- Ima: focus value obtained from active optics software system
- Psn: variable selected from TCS configuration file.
- Tmp: variable calculated by TCS. The OSS utility control system gives Tplat as an input variable for calculations.
- Off: offset input value.
- Req: is the result of adding Set+Ima+Psn+Tmp+Off
- Val: real position.

2.3 Camera Configuration Display

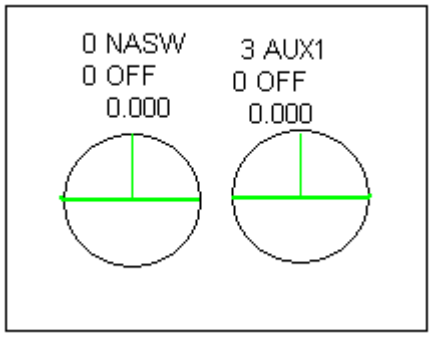
The following display shows the actual cursor position. This information is the same shown in the Guider Camera Control System Interface.



For more details see "*Guider Camera Control System User Manual*".

2.4 Rotator Position Display

The following picture shows the rotator position interface:

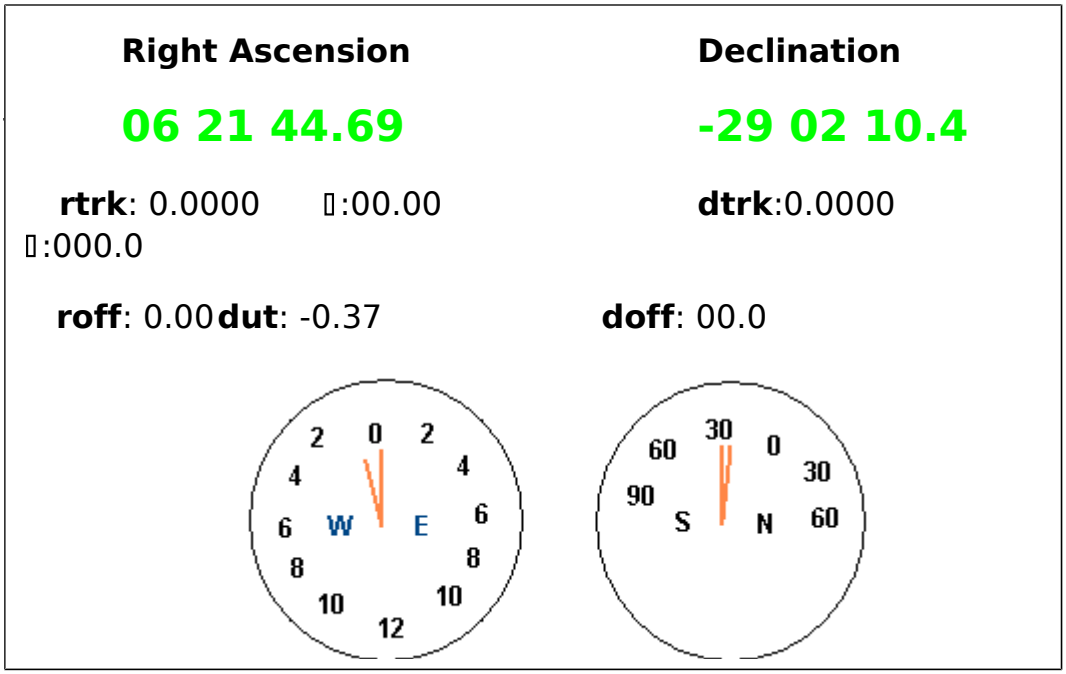


The display shows the name of the rotator: Nasw (Nasmyth west), Nase (Nasmyth east), Aux 1 (observing port 1), Aux 2 (observing port 2) and Aux3 (observing port 3). It also shows if the rotator is enabled and the target position.

2.5 Input panel Display

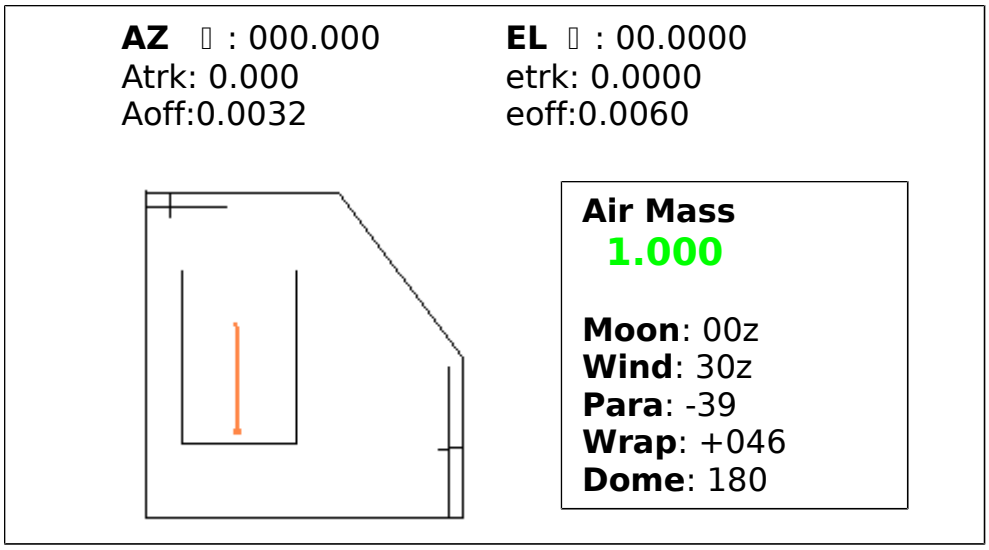
The input panel interface allows to send commands to TCS. The panel is similar to other systems, but it also shows additional information about actual values for Right ascension and declination, and future values position for the telescope.

2.6 Telescope Position Display



The variables are the following:

- Rtrk : Right ascension velocity
- Dtrk: Declination velocity
- Roff: Right ascension offset
- Doff: declination offset



The variables meaning are the following:

- Atrk: Azimuth velocity
- Etrk: Elevation velocity
- Aoff: Azimuth offset
- Eoff: Elevation offset
- Air Mass
- Moon and Wind
- Para: parallactic angle
- Wrap:
- Dome: dome position

2.7 Serial Communication Interface

This interface shows slaves information. It shows Guest Computer address and buffer information like messages read and messages to be read.

Guest Computer	**Address**
Main Drive	G1
Vane end	H2
OSS	I3
Tertiary Mirror	J4
Dome	K5
Site Utility	L6
Guider	M7
Gcam 1	N8
Gcam 2	O9
Gcam 3	P1

The interface shows the actual configuration files read by the TCS system, these are: Tcfg variable shows the number of the TCS focus configuration file to be read. Tcfg is the point model configuration file and rcfg is the rotator configuration file number.

Commands

3

3 Commands Summary

All TCS commands begin with a command code of up to four letters, followed by up to three numeric arguments. The numeric arguments (if there are more than one) are separated by spaces; spaces are permitted but not required between the command and the first numeric argument. Letters may be upper or lower case. The numeric arguments (including zero) may be negative, and may include a decimal point. For example, the commands

dc-0 25 47.2

DC -0.0 25 47.20

will both set the Dec. coordinate input to -00° 25' 47.2". The backspace key moves the cursor back one character at time. All commands are terminated by a <CR>.

3.1 Pointing Commands

Command	Description
MP n	Set the coordinate display to show mean place for the year n.
AP	Set the coordinate display to show apparent place

TP	Toggle telescope pointing model on/off.
TPON	Set telescope pointing model on
TPOF	Set telescope pointing model off
DUT n	Enter the DUT for the current date
CN n	Set the camera number to mimic in the guider box to n (1-3).
RS n	Override the automatic setting the rotator sign for the camera specified by CN on the rotator specified by RCFG. (n = +/- 1)
PF n	Override the automatic setting the parity flip for the camera specified by CN on the rotator specified by RCFG. (n = +/- 1; +1 = normal, -1 = inverted)
CA n	Override the automatic setting guide camera position offset angle for the camera specified by CN on the rotator specified by RCFG. (n degrees)
CNCA n	
SZ n	Override the automatic setting guide camera field size for the camera specified by CN on the rotator specified by RCFG. (n arcseconds)
TCFG n	Read telescope config file (pointing model) n. (n = 0... 99).

3.2 Coordinate Commands

Command	Description
RA 3n	Enter an RA coordinate
DC 3n	Enter a Dec. coordinate
AZ n	Enter an Azimuth coordinate
EL n	Enter an Elevation coordinate
CAT n	Save coordinate inputs in catalog entry n (n = 0... 99).
OBJ n	Recall coordinate inputs from catalog entry n (n = 0... 99).
SLEW [n]	Slew to highlighted (white) coordinate. Use alternate cable wrap angle if n = 2.
H	Gently halt a slew in progress
RTRK n	Set the RA tracking rate to n sec/sec.
DTRK n	Set the DEC tracking rate to n "/sec.
ATRK n	Set the AZ tracking rate to n °/sec.
ETRK n	Set the EL tracking rate to n °/sec
AOFF n	Set the AZ offset to n °.
EOFF n	Set the EL offset to n °.
CSET	Set the displayed equatorial coordinates to be the same as the input equatorial coordinates
PT	Add a pointing record (input coordinates, displayed coordinates, sidereal time) to the EDS

3.3 Offset Commands

Command	Description
OFRA n	Set the RA offset to n arcseconds. Do not move
OFDC n	Set the Dec offset to n arcseconds. Do not move
OFEP n	Set the epoch of the above offsets to n. (0 = displayed epoch, -1 = apparent)
OFFP	Move the telescope to the above offsets (positive).
OFFM	Move the telescope to the negative of the above offsets (minus).
OFFN	Immediately move the telescope North by the absolute value of OFDC
OFFS	Immediately move the telescope South by the absolute value of OFDC.
OFFE	Immediately move the telescope East by the absolute value of OFRA.
OFFW	Immediately move the telescope West by the absolute value of OFRA
RAG n	Immediately move the telescope n arcseconds in RA.
DCG n	Immediately move the telescope n arcseconds in Dec.
AZG n	Immediately move the telescope n arcseconds in azimuth
ELG n	Immediately move the telescope n arcseconds in elevation
RDG n m	Immediately move the telescope n arcseconds in RA

	and m arcseconds in Dec
AEG n m	Immediately move the telescope n arcseconds in azimuth and m arcseconds in elevation.

3.4 Focus Commands

Command	Description
ZSET n	Set the secondary focus to n microns. Also YSET, XSET
HSET n	Set the secondary tilt to n arcsec. Also VSET
ZSTR n	Set the secondary focus n microns from where it is now. (relative) Also XSTR, YSTR, HSTR, VSTR.
ZIMA n	Set the secondary focus image analyzer correction to n microns. Also YIMA, XIMA
HIMA n	Set the secondary tilt image analyzer correction to n arcsec. Also VIMA.
ZIMR n	Set the secondary focus image analyzer correction n microns from where it is now. (relative) Also XIMR, YIMR, HIMR, VIMR.
XVIR n	Set the secondary coma image analyzer corrections n microns from where they are now. (relative) Also YHIR.
AUTF	Auto-focus toggle on/off
FCFG n	Read focus config file (focus model) n. (n = 0... 99).

3.5 Rotator Commands

Command	Description
RCFG n	Set the rotator configuration for rotator n, 0 to 5 (rotator of interest). Rotator numbers 0-5: NASW NASE CASS AUX1 AUX2 AUX3
ROTO n	Set offset angle of rotator n to angle degrees. Rotator modes 0-6:
ROTM n	Set operating mode of rotator n to mode: **OFF** (no rotator command sent to vane) **HRZ** (send offset only) Hold the instrument with respect to the horizon **EQU** (send offset and parallactic angle) Hold the instrument with respect to the north **GRV** (send offset and elevation) Hold the instrument with respect to gravity. **EQZ** (send offset and parallactic angle and elevation) **HEQ** (position as in HRZ, but track as in EQU) Keeps the slit mostly vertical w.r.t the horizon, but allows you to guide off-axis. **GEQ** (position as in GRV, but track as in EQU) Keeps the instrument mostly vertical w.r.t gravity, but allows you to guide off-axis.
RM n	Like ROTM but assumes the rotator specified by RCFG
RO n	Like ROTO but assumes the rotator specified by RCFG
DR n	Add the angle to the offset angle of the rotator specified by RCFG
NRO n	Specify the offset angle of the rotator specified by RCFG for the next object.
RV n	Sets the rotator graphics orientation. Views are the same as the modes, but only 0-3.

3.6 Dome Commands

Command	Description
DOME n	Move dome to azimuth angle n.
AUTD	Automatic dome position toggle on/off. Use when tracking.
WIND n	Set the windscreen extension to n percent
MOON n	Set the moonscreen extension to n percent

3.7 Louver Commands

Command	Description
FL n m	Set fixed louver n to opening m (m = 0... 4).
RL n m	Set rotating louver pair n to opening m (m = 0... 4).
AFL n	Set all fixed louvers to opening n (n = 0... 4).
ARL n	Set all rotating louvers to opening n (n = 0... 4).
HFL n	Disable (hold) / enable commands for fixed louver n (toggle).
HRL n	Disable (hold) / enable commands for rotating louver pair n (toggle).

3.8 Other Commands

Command	Description

SM	Simulated coordinates toggle on/off (for diagnostics only).
SAVE	Save most of the data on the screen, including the catalog. Please read the explanation in the text.
VERB n m	Set report mask for device n to level m.
REM n	Set remote serial unit to device n.
LINK	Toggle operator enable/disable of TCP/IP uplink.
EXIT	Exit from the program

3.9 Message Commands

Command	Description
<Up>	Scroll system message display back one line.
<Pg Up>	Scroll system message display back one page
<Down>	Scroll system message display forward one line
<Pg Dn>	Scroll system message display forward one page
<Home>	Set system message display to show the first message
<End>	Set system message display to show the current message

3.10 Display Commands

Command	Description
<Scroll Lock>	Pause/Resume system log messages
VERB *n*	Set system log verbose level to *n* (*n* = 0 ... 2)

3.11 Detailed Explanation of Commands and Status Values

MP: Set the coordinate display to show mean place coordinates for a given year by using the MP command. The coordinate system is the FK5 (IAU 1976) system (e.g. J2000.), which is very slightly different from the FK4 (e.g. B1950.) system. However, the difference between the two systems (for example between J1950. and B1950.) is negligible. The coordinate system in use is shown just above the green RA and Dec. display.

AP: Type "AP" to set the coordinate display to show apparent place. Apparent place includes the effect of nutation (amplitude 10 arcsec) and aberration (amplitude 20 arcsec), so apparent place coordinates are NOT the same as mean place coordinates for the time of observation.

TP: The displayed coordinates will be corrected according to the telescope pointing model when TP is enabled. A green "TP" message will appear in the coordinate input box. The TP command is a toggle which will alternately turn the pointing model off or on.

DUT: The UT derived from the GPS system is UTC, with seconds of constant length derived from atomic time. The telescope really needs UT1, which is true solar time with seconds that vary slightly in length depending on variations in the rotation of the earth. The correction UT1 - UTC (up to 1 second of time) is entered using the command DUT. The correction can be found at the web site for the International Earth Rotation Service (http://maia.usno.navy.mil/eo/eo_home.html). Failure to enter the DUT will result in pointing errors of up to 15 arcseconds.

RS, PF, CA, SZ: In order to use the mouse to guide the telescope, you need to enter the position angle of the camera using the CA command. You also need to enter the size of the camera field using the SZ command. These are normally entered automatically by the CN and RCFG commands.

TCFG: Different pointing models are stored in the files TCFG.nn (nn = 00... 99). There are different pointing models for different focal stations, for example. In order to change pointing models, use the TCFG command to read in a different file. You will get a non-threatening error message if the file doesn't exist, and the old model will be left intact.

RA, DC: Enter equatorial coordinates using the RA and DC commands. The coordinates will appear in the coordinate input box. The RA and Dec. values will be highlighted (white), and the derived Az and El will be shown in black. For some positions, two alternate azimuth cable wrap angles (separated by 360°) will be shown at the "Wrap1" and "Wrap2" locations.

AZ, EL: Enter Az-El coordinates using the AZ and EL commands. The coordinates will appear in the coordinate input box. The Az and El values will be highlighted (white), and the derived RA and Dec. will be shown in black. . For some positions, two alternate azimuth cable wrap angles (separated by 360°) will be shown at the "Wrap1" and "Wrap2" locations.

SLEW: When you are sure the coordinate inputs are the ones you want, slew the telescope using the SLEW command. If the highlighted inputs are Az and El, the telescope will go to the coordinates and stop. If the highlighted inputs are RA and Dec, the telescope will go to the coordinates and track at the sidereal rate.

H: A slew can take more than two minutes. If you realize you have made a mistake, type H. The telescope will come to a controlled stop, and you can try again.

RTRK: Once the telescope is slewed to an equatorial coordinate, you can adjust the tracking rates (relative to sidereal) using the RTRK and DTRK commands. "RTRK 1" for example, will stop the telescope. "RTRK -1" will track at twice the sidereal rate. DTRK, ATRK and ETRK are similar.

CAT: The program can store coordinate input values in a catalog with entries numbered from 0 to 99. To store coordinates in entry n, type "CAT n".

OBJ: Once you have stored a set of coordinates in catalog entry n, you can quickly bring them back by typing "OBJ n".

ZSET: Enter the focus value with the command ZSET. If auto-focus is enabled, the secondary will move to the position derived from this value automatically. The YSET, XSET, HSET and VSET commands are similar.

AUTF: Toggle the auto-focus function on and off with the command AUTF. It is OK to leave the auto-focus function enabled when slewing the telescope.

FCFG: There are up to 100 different models for the focus adjustment, stored in files FCFG.nn (nn = 00… 99). In order to change focus models, use the FCFG command to read a different file. If the file doesn't exist, a non-threatening message will appear, and the previous model will be left intact. The number of the current model is displayed in the status box at the fcfg: entry.

DOME: The dome can be manually moved to a given azimuth by entering the DOME command, followed by the azimuth angle. Once the dome is moving, pressing the <esc> key should bring it to an immediate, gentle stop. (The <esc> function may not be implemented in the current version of the software).

AUTD: The dome will track the telescope automatically when the AUTD function is toggled on.

WIND: (also MOON:) The windscreen and moonroof can be moved using the commands WIND and MOON. There is no automatic function for the windscreen and moonroof positions. However, the diagram displayed on the screen is dimensionally accurate and can be used to judge whether the windscreen and moonroof clear the optical path of the telescope.

FL, RL: You can adjust a single louver on the fixed part of the enclosure, or a single pair of louvers on the rotating dome, using the FL or RL command. The arguments are the louver number and the opening in fourths. The numbering scheme of the fixed and rotating louvers is displayed in the on-screen diagram, which also shows the true azimuth orientation of the telescope and the dome. When the louvers are moving, the corresponding frame in the diagram will turn yellow. If a louver control error occurs, the corresponding frame will turn red. As the louvers open, the frame will be shaded black, one-fourth of the area at a time. The frame will turn white if a louver has been temporarily disabled using the HFL or HRL toggle commands.

AFL: (also RFL:) You can adjust all of the fixed louvers or all of the rotating louvers with the AFL and RFL commands.

HFL: (also HRL:) A single fixed louver or rotating louver pair can be taken off-line using the HFL (hold fixed louver) or HRL (hold rotating louver) commands. When a louver is off-line, it will not respond to the commands FL, RL, AFL or ARL. The color of the corresponding frame in the diagram will change to white. Repeat the HFL or HRL command to return a given louver to the on-line condition.

SM: For testing only, the coordinate inputs can be used to simulate a set of telescope coordinates using the SM command. A red "SM" message will appear in the coordinate input box. Type SM again to turn off simulated coordinates.

There is another, better way to simulate coordinates. Leave the TCS in the normal condition (SM off). Make certain that the main drives are completely disabled (for example by hitting the <Esc> key on the main drive computer). Now enter only the PS command on the main drive computer. This will enable the azimuth and elevation position profilers while leaving the actual drives and hydrostatic pads completely disabled. Most importantly, the normal main drive position servo error-checking will also be disabled. (Normally the error-checking will issue a panic shutdown if the position error is greater that .002°.) The main drive position profilers will then report the profiler position to the TCS exactly as if the telescope were really moving. The fact that the position servo errors will rise to many degrees will be ignored.

There is only one dangerous condition which can be encounterd when simulating coordinates in this way (using the main drive computer). If the instrument rotators are enabled, they will move as if the mount were actually moving, when in fact the mount will not move. It may also be necessary to disable the instrument rotators in order to guarantee the safety of instruments mounted on them.

SAVE: Most of the operator-selected parameters of the TCS program can be saved to disk at any time using the SAVE command. The saved parameters include the display epoch, choice of config files for pointing, focus and rotator models, and the catalog of objects. If you have to re-boot the computer for any reason, the program will come back with the same choice of parameters that was in effect at the time of the last SAVE command.

VERB: The low-level control computers report a constant stream of information to the TCS. Normally this information is not displayed in the TCS system message box. This corresponds to VERB level 0 for each control computer. The low level computers are assigned index numbers which are shown in the status box (Main Drive – 1, Vane End – 2, etc.). Changing VERB level to 1 for a given computer will display error messages from that computer in the TCS message box. Changing VERB level to 2 for a given computer will display all engineering data stream (EDS) messages from that computer in the TCS message box.

The number of messages received per second from each low-level computer is displayed in the status box as the first of two numbers. The messages are buffered in the low-level computers and transmitted over serial links as time allows. The second number is the maximum number of messages waiting to be transmitted in a given second of time.

REM: There is a serial port on the TCS which will transmit all of the EDS messages from a given low-level computer to a remote program which can reconstruct the low-level display screen at a remote location. The remote program can also accept commands which are relayed through the TCS to the actual low-level control computer. The remote port can be switched from one low-level computer to another with the REM command.

LINK: This will toggle the operator enable/disable of the TCP/IP uplink. If while enabled, the link is broken, the TCS will try to restore the link every 5 minutes. If you want to try to restore the link before then, toggle LINK off/on.

EXIT: To exit from the program, type "EXIT".

Configuration

4

4 TCS Configuration

4.1 Tcs.ini file, Magellan I

```
          1  ;(1)  1=Magellan 1, 2=Magellan 2    i*4
        -36  ;(2)  Cpu clock rate (ppm), +=fast  i*4
        192  ;(3)  Uplink IP address byte 1      i*4
        168  ;(4)  Uplink IP address byte 2      i*4
          0  ;(5)  Uplink IP address byte 3      i*4
          1  ;(6)  Uplink IP address byte 4      i*4
        291  ;(7)  Windscreen retract limit      i*4
        500  ;(8)  Windscreen extend limit       i*4
        100  ;(9)  Moonscreen retract limit      i*4
        789  ;(10) Moonscreen extend limit       i*4
       5600  ;(11) Uplink IP port number         i*4
;
;This is the Magellan TCS ini file.  The lines  are
;numbered from (1) to (11).  All lines MUST be present.
;The ini values are the first entries on each line,
;followed by the line numbers and the description.  Use
;a text editor to change ONLY the ini values.  Be sure
;to maintain the appropriate data type for each entry.
;
```

4.2 Tcs.ini , Magellan II

```
          2  ;(1)  1=Magellan 1, 2=Magellan 2    i*4
        -36  ;(2)  Cpu clock rate (ppm), +=fast  i*4
        192  ;(3)  Uplink IP address byte 1      i*4
        168  ;(4)  Uplink IP address byte 2      i*4
          0  ;(5)  Uplink IP address byte 3      i*4
          1  ;(6)  Uplink IP address byte 4      i*4
        291  ;(7)  Windscreen retract limit      i*4
        960  ;(8)  Windscreen extend limit       i*4
        100  ;(9)  Moonscreen retract limit      i*4
        789  ;(10) Moonscreen extend limit       i*4
       5600  ;(11) Uplink IP port number         i*4
;
;This is the Magellan TCS ini file.  The lines  are
;numbered from (1) to (11).  All lines MUST be present.
;The ini values are the first entries on each line,
;followed by the line numbers and the description.  Use
;a text editor to change ONLY the ini values.  Be sure
;to maintain the appropriate data type for each entry.
;
```

4.3 Tcs.ini Description

WindScreen retract and extend limit: are the software limits for windscreen

MoonScreen retract and extend limit:: are the software limits for moonscreen

4.4 Starting the Program

To start the TCS program, push the reset button (the black rocker switch just below the red power switch) on the computer. The program will load

automatically from the solid-state disk. Resetting the computer assures that the system will start each time in the proper state.

Note that the UT date is initialized from the internal computer clock, which MUST be set to the correct UT date and UT time. If the date is wrong, then the displayed sidereal time will be off by at least four minutes. To reset the date, check the CMOS setup of the PC. Enter the CMOS setup routine by pressing <del> on the keyboard a few seconds after pressing the reset button.

4.5 Coordinate Entry

In order to slew the telescope, the desired coordinates must first be entered into the coordinate input box. The telescope will not move until the SLEW command is entered. The coordinate input box displays both Az-El and equatorial coordinates. If an azimuth or an elevation angle has been entered most recently, the Az and El coordinates will be highlighted in white, and the TCS will calculate the corresponding RA and Dec (as a function of time) and display them in black. If an RA or Dec coordinate has been entered most recently, the RA and Dec coordinates will be highlighted in white, and the TCS will calculate the corresponding azimuth and elevation angles (as a function of time) and display them in black.

The telescope will not slew to an elevation angle below 10°, or to an equatorial coordinate within 0.4° of the zenith. If either of these conditions occur, the value of the elevation angle will be shown in red. The epoch of the equatorial coordinates in the coordinate input box is the same as the epoch of the equatorial coordinates of the main telescope coordinate display.

The coordinate inputs are also displayed as the red pointers in the equatorial coordinate dials and in the azimuth and elevation diagrams. The current position of the telescope is displayed as the black pointers in the equatorial dials, and as the U-shaped figures (drawn approximately to scale) in the azimuth and elevation diagrams.

The telescope will slew to the desired coordinates when the SLEW command is entered. If Az-El coordinates have been entered, the telescope will move to the desired coordinate and then stop. If equatorial coordinates have been entered, the telescope will slew to the desired coordinates and then track at the sidereal rate.

4.6 Using the Trackball

Small adjustments to the telescope position can be made using the trackball. Moving the trackball moves a red pointer in the small rectangular diagram on the TCS display. The diagram is intended to represent the field of the TV viewer. The TCS must be informed about the size and orientation of the TV display using the SZ, RS, PF and CA commands. These are usually set automatically by the RCFG and CN commands, but may be overridden by the operator for testing. The trackball will also move xy1 on the guide cameras.

Also, in the small rectangular diagram, you will see two colored L-shaped marks. The red one in the upper left shows the orientation of the elevation and azimuth axes. The longer arm shows the +elevation direction and the shorter arm shows the +azimuth direction. The green one in the upper right shows the orientation of the declination and right ascension axes. The longer arm shows the north direction and the shorter arm shows the east direction.

To move a given object in the TV field to the center of the square box, move the trackball pointer to the position in the diagram which corresponds to the position of the object in the TV field. Then press the right button on the trackball and click the left button. The telescope will move so that the object appears in the center of the square box. If you click the left button without pressing the right button, the object will move only one-tenth of the distance to the center of the square box. You can introduce small guiding motions by moving the pointer close to the center of the square box, and clicking just the left button. The square box follows the position of the guide box (xy5) on the guide camera specified by CN.

4.7 Secondary Mirror Focus and Colimation

The vane-end actuators control 5 degrees of freedom of the secondary mirror: focus (Z), collimation (X, Y), and tip/tilt (H, V). The TCS computer will send commands to the vane-end system to automatically maintain focus, collimation and tip/tilt as the telescope moves in elevation, according to the particular focus model which is loaded with the command FCFG.

The actual value for each of the 5 adjustments is derived from the sum of several parameters which are shown in the focus box on the TCS display. Each adjustment has a nominal set point which is the value with the telescope pointing to the zenith (set:). To this value is added the cumulative magnitude of any adjustments requested by the image analyzer (ima:), and the value of the flexure term at the current position (psn:), as derived from the focus model. The focus adjustment is particularly sensitive and includes an additional correction for temperature (tmp:), as well as an offset term which allows a correction to be introduced manually, for example to

compensate for the focus change for different filters in a direct camera (off:). The temperature correction is zero at a nominal temperature of 12°

The derived setpoint for each of the 5 adjustments is shown as the requested (req:) value. For comparison, the actual position of the vane-end assembly is also shown (val:). If the automatic focus function is switched on using the AUTF toggle, the vane-end assembly will constantly seek to the requested values.

4.8 How to Take Data to Check or Update the Pointing Model

A good check of the pointing model requires 30-50 observations, and a good set of data for deriving a new pointing model requires 100 or so. Each setting will require about 2 minutes, so the best thing to do is to get organized in a systematic way. Plan to start an hour or two late, so that the telescope will have time to come to thermal equilibrium after the dome is opened.

While you are waiting (or during the afternoon), choose a set of stars from the SAO catalog or the Astronomical Almanac. Pick a set of stars at approximately the same RA which will place them about 4.5 hours east when you begin, and spaced in declination by about 15 degrees between +35 and -85. Pick another set which will be on the meridian at the beginning of the night, spaced in declination in the same way. Finally, pick 3 or 4 stars which are 1 hour further east than the first set, between -40 and -85, and 3 or 4 stars which are 1 hour further west than the second set, between -40 and -85. Number the stars in order of declination within each set (keeping separate the extras which are 1 hour over), and make a list with their catalog positions and proper motions.

Now observe the 3 or 4 stars which are furthest east. When each star is centered on the crosshairs, record the RA and Dec. coordinates with TP turned off, and the sidereal time (which is used to derive the hour angle). Next observe the east star list, working from the pole to the equator, and then the meridian star list, working from the equator to the pole. Repeat the two lists as the night goes by, but don't repeat the 3 or 4 which are furthest east. Gradually the east list will end up on the meridian, and the meridian list will end up 4.5 hours west. After half a night, do the 3 or 4 stars which are furthest west (again only once), and then you are done.

Of course the stars which are furthest north in each list will not be accessible at extreme hour angles. You only need to do these when it makes sense.

4.9 Acknowledgement

The TCS program makes extensive use of the SLALIB and TPOINT program libraries, which were developed and graciously provided by Pat Wallace of STARLINK.

Serial Communication

5

5 Control System Serial Communication Standards

There is always a host (upstream) computer, and a guest (downstream) computer. The host computer is frequently the TCS, with the guest being Main Drive, Vane End, Oss, Tertiary Mirror, Dome, Site Utility, guider and guider camera computers. The host system sends a command, and the guest responds immediately to that command. Guest computers never broadcast without being queried, which allows multiple guests to be chained on the same serial line.

Full command format:

:Nnddddddddddccr

The "**:**" is the prompt character to initiate communication. **N** is the guest computer's unit address. **n** is a command number, **d**'s are data specific to the command (variable length), **cc** is a checksum, and **r** is a carriage return (ASCII 13).

Full response format:

~Nnddddddddccr

The "**~**" is the response character for guest computer responses. **N** is the guest computer's unit address. **n** is the command number this is in response to, **d**'s are data specific to the response (variable length), **cc** is a checksum, and **r** is a carriage return (ASCII 13).

For very short commands and responses the checksum may be omitted (this is noted in the command description).

For all commands and responses that include a checksum, the checksum is composed of two hexadecimal digits (from 0-F). The checksum is calculated by starting with zero and XORing it with all characters in the message from the unit letter to the last data character before the checksum (the underlined part of the command and response above).

Commands that are received but misunderstood (checksum wrong, unknown command, etc) are replied to like this:

~N?r

Most guest computers maintain a running system log that contains important messages and all system status information. Each also maintains a pointer into that log that keeps track of the oldest message that hasn't been sent to the host computer. The "2" and "3" commands let the host computer command the guest computer to transmit one of its log entries or re-transmit the last entry. This is referred to as the "Engineering Data Stream", or EDS.

Command Summary:

2: Query Next EDS Message

3: Repeat Last EDS Message

4: Set UT

9: Free-form Command

5.1 Command Description

5.1.1 2: Query Next EDS Message

Commands the guest computer to send its oldest un-sent EDS log entry, and advance its internal pointer to the next EDS log entry.

Command Format: :N2r (note that this command has no checksum)

Response Format: ~N2qqnnttttttttfffddddddccr

N Guest computer address (usually an upper-case letter)

qq Two-digit number of EDS messages left in the guest queue

nn Two-digit number of characters in the message (in the underlined section). 00 if no message available

tttttttt Eight-digit message time stamp (no punctuation), with two-digit hour, two-digit minute, two-digit second, and two-digit hundredths of a second.

fff Three-digit message number. Message numbers from 0-799 denote errors, 800-899 are numberical data formats, and 900-999 are successes

ddddddd Variable length message data section. For error and success messages, typically a simple text message. For numeric data formats, a combination of ASCII, decimal, and hexadecimal characters/digits, with the format being determined by the particular message number

cc Checksum, described above.

r ASCII charater 13, a carriage return.

5.1.2 3: Repeat Last EDS Message

Commands the guest computer to re-send the last message it sent (implying that the host computer had a serial communication error during the last reponse). The guest's internal pointer should remain unchanged.

Command Format: :N3r (note that this command has no checksum)

Response Format: ~N3qqnnttttttttfffddddddccr

N Guest computer address (usually an upper-case letter)

qq Two-digit number of EDS messages left in the guest queue

nn Two-digit number of characters in the message (in the underlined section). 00 if no message available (there is no time stamp, message number, or data in this case).

tttttttt Eight-digit message time stamp (no punctuation), with two-digit hour, two-digit minute, two-digit second, and two-digit hundredths of a second.

fff Three-digit message number. Message numbers from 0-799 denote errors, 800-899 are numberical data formats, and 900-999 are successes.

ddddddd Variable length message data section. For error and success messages, typically a simple text message. For numeric data formats, a combination of ASCII, decimal, and hexadecimal characters/digits, with the format being determined by the particular message number.

cc Checksum, described above.

r ASCII charater 13, a carriage return.

5.1.3 4: Set UT

Commands the guest computer to set its clock to the Universal Time given in this command. The control computers keep their clocks synchronized to GPS-provided universal time in this way.

Command Format: :N4tttttttccr

Response Format: ~N4er (note that this response has no checksum)

N Guest computer address (usually an upper-case letter)

tttttttt Eight-digit universal time (no punctuation), with two-digit hour, two-digit minute, two-digit second, and two-digit

hundredths of a second.

cc Checksum, described above.

r ASCII charater 13, a carriage return.

e Error flag: 0 if an error occurred, 1 if OK.

5.1.4 9: Free-form Command

Sends the guest computer a free-form command, typically similar to the commands entered via the guest computer's keyboard. This is used to command moves, homes, etc.

Command Format: :N9nnddddddccr

Response Format: ~N9ennmmmmccr

N Guest computer address (usually an upper-case letter)

nn Two-digit number of characters in the message (in the underlined section). 00 if no message available.

ddddddd Variable length free-form command section. This section will contain a command parseable by the guest computer, such as "MOVE 1000"

cc Checksum, described above.

r ASCII charater 13, a carriage return.

e Error flag: 0 if OK, 1 or higher if an error occurred

mmmm Variable length diagnostic message (such as "Move ignored, brake on"). This should be printed out by the host computer in the command input box if the command was given by the user, or in the system log if the command was given by an automated routine in the host program. nn=00 in the response if there is no diagnostic

message.

5.2 Slaves Systems vs Tcs Control Software Communication commands

There are another commands format and response from slaves systems that allows TCS system to send command request . The slaves systems always sent an answer showing the results of command execution. Remember that almost all jobs are done by slaves. TCS manages their slaves using the following communication protocol.

5.2.1 Dome Control Software

8: TELESCOPE ELEVATION INFORMATION

TCS control software sends telescope elevation information every 30 seconds. This information is used to move windscreen and moonscreen.

Command Format: :K8nnnnnnccr

Response Format: ~K8fr

K Dome computer address (usually an upper-case letter)

8 This number indicates to dome control software that information sent is about telescope elevation information.

nnnnnn This is the elevation value.

f Is the reply flag sent to TCS control software. If f =1 then the elevation value was read by dome software without problems. If f = 0 the elevation information was not received in perfect condition (checksum is bad, command sent by Tcs is corrupted, etc).

cc Checksum, described above.

r ASCII charater 13, a carriage return.

5: DOME POSITION

TCS control software sends new dome position.

Command Format: :K5ppppeeeftccr

Response Format: ~K5mr

K Dome computer address (usually an upper-case letter)

5 This number indicates to dome control software that information sent is about new position that dome control software should execute.

pppp This is the elevation value.

eee Position error.

f Flag: 1, 2, 3, or 5, 6, 7.

t number of position iterations

m Is the reply flag sent to TCS control software. If f =1 then the dome position command was accepted. If f = 0 the information was not received in perfect condition (checksum is bad, command sent by Tcs is corrupted, etc). If f = 2, command is ignored (another motion was executed).

cc Checksum, described above.

r ASCII charater 13, a carriage return.

1: LOUVER COMMANDS

Tcs control software sends a complete command sequence for 18 louvers, positions from 1 to 10 for rotating louvers, and positions from 11 to 18 for

fixed louvers. If there is no new louver motion, the Tcs control software don't sent any louver command sequence.

Command Format: :K1aaaaaaaaaaaaaaaaaccr

Response Format: ~K1mr

K	Dome computer address (usually an upper-case letter)
1	This number indicates to dome control software that information sent is about telescope louvers information.
aaaaaaaaaaaaaaaaa	All louvers commands
f	Reply flag sent to TCS control software. If f =1 then the louver command was read by dome software without problems. If f = 0, information was not received in perfect condition (checksum is bad, command sent by Tcs is corrupted, etc).
cc	Checksum, described above.
r	ASCII charater 13, a carriage return.

5.2.2 Vane end Control Software

5.2.3 Guider Control Software

5.2.4 SiteUtil Control Software

5.2.5 M3 Control Software

5.2.6 OSS Control Software

Log Message System

6

6 Log Message System

This is a numerical index of all error messages from the Magellan telescope control program.

6.1 Errors (000-799)

000: DOS date error, code = XXX

001: Louver command data error

002: Louver command com error X

003: Louver message length error

004: Dome UT set data error

005: Dome UT set com error X

007: Dome EDS length error

008: Dome EDS data error

009: Dome EDS com error X

010: Dome error messages suspended

011: Left louver EDS length err

012: Right louver EDS length err

013: Fixed louver EDS length err

014: Dome drive EDS length error

015: Dome position data error

016: Dome position com error X

017: UPLC EDS length error

018: Moonscr/Windscr data error

019: Moonscr/Windscr com error X

020: Elevation zenith limit

021: Elevation horizon limit

022: Sidereal tracking zenith limit"

023: Servo error: slew aborted

024: Slew aborted

026: Az rate exceeded near zenith

027: Lift/Hatch EDS length err

030: Main Drive error msgs suspended

031: Main Drive UT set data error

032: Main Drive UT set com error X

033: Main Drive position decode error

034: Main Drive position data error

035: Main Drive position com error X

036: Main Drive EDS data error

037: Main Drive EDS com error X

038: Main Drive velocity cmd rejected

039: Main Drive vel cmd data error

040: Main Drive vel cmd com error X

041: Main Drv jog cmd transmit error

042: Main Drive jog command rejected

043: Main Drive jog cmd data error

044: Main Drive jog cmd com error X

045: Main Drive continue cmd rejected

046: Main Drive continue cmd data err

047: Main Drv continue cmd com err X

048: Main Drive stop command data err

049: Main Drive stop cmd com error X

050: Motion stopped by operator

051: Main drive EDS length error

060: GPS serial com error X

061: GPS message length error

062: GPS time stamp error

063: GPS consistency error

064: GPS error messages suspended

070: Vane End error msgs suspended

071: Vane End UT set data error

072: Vane End UT set com error X

073: Vane End rem cmd com error X

074: Vane End rem cmd data error XX

075: Vane End global cmd function err

076: Vane End EDS data error XX

077: Vane End EDS com error X

078: Vane End global cmd check error

079: Vane End global cmd reply error

080: Vane End global cmd com error X

081: Vane End EDS length error

082: Vane Global EDS length error

083: Reply =

093: Remote error messages suspended

094: Remote command checksum error

095: Unrecognized remote command

096: Remote command length error

097: Remote command time-out

101: TCP Open Socket failure

102: TCP connection timeout

103: TCP write socket error XXX YYY

104: TCP connection broken

105: TCP error messages suspended

110: Site Util error msgs suspended

111: Site Util UT set data error

112: Site Util UT set com error X

113: Site Util rem cmd com error X

114: Site Util rem cmd data error XX

116: Site Util EDS data error XX

117: Site Util EDS com error X

121: Site Util EDS length error

130: OSS Util error msgs suspended

131: OSS Util UT set data error

132: OSS Util UT set com error X

133: OSS Util rem cmd com error X

134: OSS Util rem cmd data error XX

136: OSS Util EDS data error XX

137: OSS Util EDS com error X

141: OSS Util EDS length error

142: OSS temperature EDS length error

151: Focus config error at line XX

155: Telescope config err at line XX

156: Number of gterms exceeded

157: Number of sterms exceeded

6.2 EDS Log Data Format (800-899)

801: Information about observation date

Format: 801yyyy-mm-dd hh ii ss HH II SS aaaaaaaaaabbbbbbbbbbccccccc

yyyy-mm-dd: Observation date

hh ii ss: UT

HH II SS: ST

aaaaaaaaaa: Right ascension

bbbbbbbbbb:Declination

ccccccc: Epoch

802: Information about Telescope position

Format: 802aaaaaaaaaabbbbbbbbbccccccccmmmmmmxvvvvvvvvvvyzuuuuuum

aaaaaaaaaa: ha

bbbbbbbbb:Azimuth

cccccccc: Elevation

mmmmmm: Airmass

x: Rotator of interest

vvvvvvvvv: Rotator encoder plus/minus parallactic angle, depending on rotator[1]

y: Slew flag

z: Track flag

uuuuuu: Current focus in user coordinates

m: Rotator servo flag

803: Tcs coordinates inputs in control program

Format: 803aaaaaaaaaaabbbbbbbbbbbccccccccccddddddddddeeeeeeee

aaaaaaaaaa: Telescope right ascension (telra) (pointing tests)

1 Equivalent to the rotator offset in rotator mode 2 (EQU), the normal operating mode of the rotator.

bbbbbbbbbbb: Telescope declination (teldc)

ccccccccccc: inpra (input right ascension)

ddddddddddd: inpdc (input declination)

eeeeeeee: st

804: Coordinates inputs in control program

Format: 804aaaaaaaaaaabbbbbbbbbbbzzzzzzzzzfffffffhhhhhhhh

aaaaaaaaaaa: inpra

bbbbbbbbbbb: inpdc

zzzzzzzzz: inpaz (input azimuth)

hhhhhhhh: inpel (input elevation)

805: Information about Vane end status program for TCS

Format: 805ddddddddaaaaaaaaabbbbbbbbbppppppppzzzzzzzzztttttttt

ddddddddd: dome azimuth

aaaaaaaaa: rotpos (rotator encoder angle of input coordinates)

bbbbbbbbb: inppad (parallactic angle of input coordinates)

ppppppppp: rotpa (parallactic angle of current target)

zzzzzzzzz: rotpah (parallactic angle of target in one hour)

tttttttt: rotofh (current rotator offset, except in rotator modes 5 and 6)

806: Instrument rotator information

Format: 806aaaaaaaaabbbbbbbbbccccccccfffffffffggggggggghhhhhhhhh

aaaaaaaaa: gangle (rotator gravity angle for current view mode)

bbbbbbbbb: hangle (rotator horizon angle for current view mode)

cccccccc: eangle (rotator encoder angle for current view mode)

fffffffff: pangle (rotator encoder angle of input coordinates for current view mode)

ggggggggg: fangle (rotator encoder angle in one hour for current view mode)

hhhhhhhhh: nangle (parallactic angle for current view mode)

807: Main Drive velocity commands

Format: 807aaaaaaaaabbbbbbbbb

aaaaaaaaa: 1.d8 * (azpv + 5.d0) degrees/second

bbbbbbbbb: 1.d8 * (elpv + 5.d0)

808: Main Drive jog commands

Format: 808aaaaaaaaabbbbbbbbb

aaaaaaaaa: 1.d6 * (azpj + 500.d0) degrees

bbbbbbbbb: 1.d6 * (elpj + 500.d0)

809: Camera angles information

Format: 809aaaabbbbdddd

aaaa: camera angle 1

bbbb: camera angle 2

dddd: camera angle 3

820: Z axis M2 position information

Format: 815aaaaaabbbbbbccccccddddddeeeeeefffffffgggggg

aaaaaa: Z set

bbbbbb: Z ima

cccccc: Z psn

dddddd: Z tmp

eeeeee: Z off

ffffff: Z req

gggggg: Z val

821: Y axis M2 position information

Format: 816aaaaaabbbbbbccccccddddddeeeeee

aaaaaa: Y set

bbbbbb: Y ima

cccccc: Y psn

dddddd: Y req

eeeeee: Y val

822: X axis M2 position information

Format: 817aaaaaabbbbbbccccccddddddeeeeee

aaaaaa: X set

bbbbbb: X ima

cccccc: X psn

dddddd: X req

eeeeee: X val

823: H axis M2 position information

Format: 818aaaaaaaaabbbbbbbbbccccccccddddddddddeeeeeeeee

aaaaaaaaa: H set

bbbbbbbbb: H ima

ccccccccc: H psn

ddddddddd: H req

eeeeeeeee: H val

824: V axis M2 position information

Format: 819aaaaaaaaabbbbbbbbbccccccccddddddddddeeeeeeeee

aaaaaaaaa: V set

bbbbbbbbb: V ima

ccccccccc: V psn

ddddddddd: V req

eeeeeeeee: V val

6.3 Successes (900-999)

966; ffffffff nnnnnnnn vvvvvvvvvvv

```
967;                nnn vvvvvvvvvvv

968; (title)

969; Reading config file tcfg.nn

972; Remote error messages resumed

973; OSS Util error msgs resumed

974; Site Util error msgs resumed

979; TCP error messages resumed

980; TCP socket opened

981; Slew complete

982; Slew complete:  t = xxx.x sec

984; Slew hh mm ss.ss ddd mm ss.s

985; Estimated slew time xxx.x sec ;x

986; Slew xxx.xxxx xx.xxxx (xxxx)

988; Sim. aaa.aaaa ee.eeee

989; Sim. hh mm ss.ss ddd mm ss.ss

990; TCP connection established

991; TCP buffer size = XXXX

992; TCP buffer address = XXXXXX

993; Remote error messages resumed

994; Vane End error msgs resumed

995; UT set by GPS to HH MM SS.00

996; GPS error messages resumed

997; Main Drive error msgs resumed

998; MGTCS initialization complete

999; Dome error messages resumed
```

System Details

7

7 Telescope Control System differences between Magellan I and II

Troubleshooting

8

8 Troubleshooting